## REMARKS

This is intended as a full and complete response to the Office Action dated October 20, 2003, having a shortened statutory period for response set to expire on January 20, 2004.

### Background

In view of the Examiner's comments in the subject office action and in previous office actions, Applicants feel it necessary to review some of the most basic elements and concepts of nuclear physics:

1. Neutrons and gamma rays are *not* the same. Briefly stated and without delving into the quantum mechanical wave properties of mass and energy, (a) a neutron has mass and is without electrical charge, and (b) a gamma ray is without mass (except through the equivalent mass energy relationship $E = mc^2$) and without electrical charge. In this and previous office actions, the Examiner seems to confuse and co-mingle the two types of radiation on numerous occasions.

2. Neutron sources emit neutrons. Gamma ray sources emit gamma rays. As an example, cesium-137 ($^{137}Cs$) is a gamma ray source, and does not emit neutrons. Decay schemes of isotopic sources can be found in most elementary nuclear physics texts, and in such displays as the chart of the nuclides, which is the nuclear physic equivalent to the chemist's periodic chart. The Examiner apparently fails to recognize the difference radiation sources, as is evidenced by the statement at page 11, lines 10-11:

> "Additionally, it is also well known in the art that a cesium-137 source is a *neutron* source."

This statement is, of course, erroneous.

3. Since neutrons differ from gamma rays, neutron detectors differ from gamma ray detectors. Neutron and gamma ray detectors can not be interchanged at will. A response of neutron detector to neutron radiation differs from a response of gamma ray detector to gamma radiation. The Examiner continues to interchange neutron and gamma ray detectors as evidenced (among other places) at page 10, lines 5-9. The Examiner refutes Applicant's position in the previous Office Action Response that *Evans* does *not* teach normalization of a first gamma ray spectrum with a second gamma ray spectrum by reciting col. 2, lines 33-34, stating:

> "The normalized intermediate-spaced epithermal ***neutron*** detector output and the normalized far-spaced detector output are combined"

This is exactly Applicant's point! Both *Evans* and now *the Examiner* recite the combination of an intermediate-spaced epithermal ***NEUTRON*** detector output with a

normalized far-spaced detector. This is not the same as combining two *gamma ray* spectra, as the instant invention teaches and claims. The instant invention does *not* teach, require, or suggest the use of a ***NEUTRON*** detector. The near-spaced detector 62 of *Evans* is clearly defined as an epithermal *neutron* detector, e.g. a $^3$He proportional counter (see col. 7, lines 1-6 and throughout *Evans*). How can the *difference* between *Evans* and the instant invention be summarized more clearly than the comment by the Examiner at col. 2, lines 33-34? There are other examples too numerous to quote in this and previous Office Actions where the Examiner fails to recognize a difference in neutron and gamma ray detectors.

4. Down scattered gamma radiation is not the same as thermal capture gamma radiation or inelastic scatter gamma radiation or induced gamma radiation. Down scattered neutron radiation is not the same as down scattered gamma radiation. In view of comments at page 2, last four lines, (and in other comments in this and previous Office Actions) the Examiner seems to confuse these types of radiation.

To summarize, Applicant finds it extremely difficult to discuss grounds for claim rejection in light of the Examiner's apparent misinterpretation of basic nuclear physics. Applicant respectfully requests that the Examiner carefully review the cited references, and then reconsider ground for rejection in view of the basic nuclear principles discussed only briefly above in the Background section.

## Claim Rejections Under 35 U.S.C. § 102(b)

Claims 1-7 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,804,820 to Michael L. Evans et al (*Evans '820*). Once again, Applicant respectfully traverses the rejections.

*Evans '820* discloses a system for determining density of earth formation. The *Evans '820* system detects *both* ***neutron*** *and gamma ray signals.* These ***neutron*** *and gamma ray signals* are analyzed and *combined* to determine the density of an earth formation. This is recited in lines 8-10 of the abstract, and taught throughout the disclosure. It is emphasized that the *Evans '820* apparatus comprises *both* neutron *and* gamma ray detectors, *both* neutron *and* gamma ray signals are measured, and *measures of both neutron and gamma ray signals are required to obtain a measure of formation density*.

The instant invention is also a system for measuring earth formation. The instant system, however, uses *only* gamma ray detectors, and *only* gamma ray signals are (and can) be used to obtain a measure of formation density. The instant invention is similar to the *Evans '820* system *only* in that both systems measure formation density. Basic measurement principles differ. Apparatus differs. Data processing differs.

The *differences* in *Evans '820* and the instant system can best be seen by again using the Examiner's comments of the present Office Action as a template. The elements of the claim 1 are compared with the *Evans '820* reference using teaching cited by the Examiner.

1. A method for determining a property of a material, comprising the steps of:

(a) inducing, within said material, gamma radiation comprising energies greater than about 3 MeV;

**Examiner's references:** Abstract, lines 1-7 and col. 8, lines 62 to col. 9, line 5.
**Applicant's comments**: There is no teaching of inducing gamma radiation at energies greater than about 3 MeV in the abstract. Regarding col. 8, lines 62 to col. 9, line 5, measurement of gamma radiation in the 0.1 to 11 MeV range is used in gamma ray *spectral analysis* to derive information concerning elemental composition (not density) of the formation under investigation (see col. 9, lines 2-5).

(b) measuring a first gamma ray spectrum and a second gamma ray spectrum resulting from said induced gamma radiation;

**Examiner's references:** The Examiner cites five references, with most including the measure of *neutrons*.
**Applicant's comments**: There is teaching in *Evans '820* of measuring two gamma ray spectra at two different axial spacings. Detector 66d is used to obtain gamma ray spectral data to determine formation elemental concentration (col. 9, lines 6-9). Detector 84 is a gamma ray detector which is positioned relative to the neutron source so as to be sensitive to MeV neutrons (or, preferably, MeV induced gamma rays) that penetrate relatively far distances in the formation (see col. 10, lines 34-39). *Evans* does *not* teach the measure of a first and a second gamma ray spectrum with these detectors.

(c) normalizing said first and said second gamma ray spectrum in a first energy region;

**Examiner's references:** Abstract, lines 7-8; col. 2, lines 41-65; col. 7, lines 19-49; and col. 10 lines 31-56.
**Applicant's comments**: Once again, there is *no* teaching of spectral measurement or normalization of spectra in the abstract. Near, intermediate and far spaced gamma ray *and* neutron detectors are discussed at col. 2, lines 41-65. The instant invention uses *only* gamma ray detectors. *Evans '820* does *not* teach *normalizing* two gamma ray spectra. *Neutron* detector normalization is taught at col. 2, lines 32-37, but as discussed above, neutron detectors are different from (and are certainly *not* equivalent to) gamma ray detectors. Gamma ray detector output is normalized for fluctuations in source *neutron* output (col. 2, lines 30-32). Once again, the Examiner erroneously treats neutron and gamma ray detectors as equivalent. They are not equivalent. Col. 7, lines 19-49 are devoted only to the discussion of *neutron* detectors. Recall once again that the instant invention uses only *gamma ray detectors*. Col. 10, lines 31-56 do not teach or suggest normalization of a first and a second *gamma ray* spectrum.

(d) measuring down scatter gamma radiation in a second energy region of said normalized first and second gamma ray spectra; and

**Examiner's references:** None.

**Applicant's comments**: As discussed above, *Evans '820* does not teach *gamma ray* spectral normalization, thus does not teach measure of down scatter gamma radiation in a second region of *normalized* spectra.

(e) determining said property from said measure of down scatter radiation.

**Examiner's references:** Abstract, lines 8-10; col. 2, lines 11-65; col. 4, lines 18-46; col. 9, line 6 to col. 10, line 46; and col. 12 lines 11-27.

**Applicant's comments**: Applicant seems to be unclear concerning the definition of down scatter gamma radiation (see item 4 of Background above). There is no mention of down scatter gamma radiation in the abstract or any of the cited material. Briefly, col. 2, lines 11-65 disclose detector functions as discussed previously, col. 4, lines 18-46 discuss basic concepts behind the *Evans '820* measurement, col. 9, line 6 to col. 10, line 46 discuss the function of gamma ray detector 66d as mentioned previously, and col. 12, lines 11-27 discuss the mechanics of *fast neutron* transport through material. *Not one of the cited references teaches the use of down scatter gamma radiation and the determination of a property from such radiation.*

Regarding claim 3, the Examiner states that *Evans '820* discloses a first gamma ray spectrum (near spaced detector 62 shown on Fig. 2 and near spaced detector 130 shown on Fig. 9). The detector 62 is a *neutron detector* (see col. 7, lines 1-49) and *can not* yield a first *gamma ray* spectrum. Once again, the Examiner erroneously treats neutron and gamma ray detectors as being equivalent. The detector 130 is a gamma ray detector. Close inspection, however, shows that equations (1) through (9) contain a *neutron source term* that can fluctuate, as disclosed by *Evans '820*. Correction for source fluctuation is made with a measured *neutron* flux obtained with a *neutron detector* (see col. 13, lines 45-46). Stated another way, at least one of the previously discussed neutron detectors of the *Evans '820* system must be used to monitor neutron source output, and monitored neutron output is used to correct density measurements for adverse effects of neutron source fluctuation. The instant invention does *not* require a neutron detector, or the monitoring of neutron source output.

In view of the above comparisons, claims 1, and 3 are clearly *not* anticipated by *Evans '820*. Claims 2 and 4-7 are dependent upon claim 1. In view of the discussion related to claims 1, dependent claims 2 and 5, 6-7 are clearly *not* anticipated by *Evans '820*. The Examiner is respectfully requested to reconsider rejection of claims 1-7 under 35 U.S.C. § 102(b) as being anticipated by *Evans '820*.

Claims 8, 9, 11, 13-16, 18, 19, 21, and 24-26 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 3,864,569 to Jay Tittman (*Tittman*). Applicant respectfully traverses the rejections.

*Tittman* discloses a logging system for measuring density of earth formation penetrated by a well borehole. The *Tittman* logging instrument comprises a *gamma ray* source 21. The source is preferably $^{137}Cs$, which emits *gamma radiation* at about 660 KeV or 0.660 MeV (see col. 3, lines 48-54). Two axially spaced gamma ray detectors are used to measure gamma radiation emitted by the source and *down scattered* by the

formation. These measures of *down scattered gamma radiation* are combined to yield a measure of formation density

*Tittman* and the instant invention utilize completely different apparatus and methods to obtain formation density measurements. The *Tittman* system also has operational limitations while the instant invention can be operated in a much wider range of conditions, as will be discussed subsequently. As stated previously, the *Tittman* system obtains a formation density measurement by detecting gamma radiation that is emitted by a *gamma ray source* and is subsequently *down scattered* into the well borehole. The instant invention obtains a formation density measurement by detecting gamma radiation *induced* in formation by a *neutron source*. *Tittman* uses relatively low energy gamma radiation, which is less than the maximum source energy. The maximum source energy is about 0.660 MeV for the preferred cesium-137. The *Tittman* gamma ray source and two axially spaced gamma ray detectors are contained within an expandable, articulating pad that follows the wall of the borehole. The instant invention measures higher energy gamma radiation (e.g. 4.43 MeV). The *Tittman* system is limited to wireline logging applications. The instant invention can be uses both in wireline logging and in logging-while-drilling operations.

As in the first and second office action, the Examiner in paragraph 2, section 4 of the present office **MISQUOTES** *Tittman* in citing at col. 2, lines 40-41 and col. 3, lines 49-54, that *Tittman* discloses an apparatus for measuring a property of material, comprising a *neutron* source. ***Tittman* clearly discloses and recites a *gamma ray* source.** Neutron and gamma ray sources are different, as discussed in the Background above. This is obvious to those skilled in the art. Neutron and gamma ray sources are different and certainly not equivalent in the design of nuclear logging systems. ***Applicant knows of no way to further or more strongly emphasize this fact.*** The Examiner is still treating neutron and gamma ray sources as *equivalent*, as she has treated neutron and gamma ray *detectors* as equivalent. *Neutron and gamma ray sources are not equivalent. Tittman* employs a *gamma ray* source, and the instant invention employs a *neutron* source.

Regarding claims 8, 9, 11, and 13-16, independent claims 8 clearly recites inducing gamma radiation by means of a *neutron* source at element (a), and detecting gamma radiation *induced* by the *neutron* source at elements (b) and (c). Again note that col. 2, line 41 specifically recites that the *Tittman* tool contains a *gamma ray* source. Furthermore, col. 3, lines 49-54 specifically recite a $^{137}$Cs gamma ray source. **$^{137}$Cs is not a neutron source, as erroneously stated by the Examiner at page 11, lines 10-11.** Independent claim 8 is, therefore, clearly distinguished over *Tittman*. Claims 9, 11, 13-16, which depend upon independent claim 8, are also clearly distinguished over *Tittman*.

Regarding claims 18, 19, 21, 24, and 25, independent claim 18 clearly recites a neutron source at element (a). Once again, the Examiner **MISQUOTES** *Tittman*. **Once again, the *Tittman* tool comprises a gamma ray source.** Once again, neutron and gamma ray sources are different. Claim 18, and dependent claims 19, 21, 24, and 25 are therefore clearly distinguished over *Tittman*.

## Claim Rejections Under 35 U.S.C. § 103(a)

Claims 10, 20 and 22 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view of U.S Re. 36,012 to William A. Loomis et al (*Loomis*). Applicant respectfully traverses the rejections.

*Loomis* discloses a logging system that is designed to measure a variety of formation parameters, including density and porosity, by detecting neutron and gamma radiation induced within the formation by a neutron source. Gamma radiation up to 10 MeV is measured. A bottom hole assembly 36 houses a neutron accelerator type source 58 and clusters of axially spaced detectors comprising *both neutron and gamma ray detectors* (e.g. 66a, 66b, 66c and 66d). The bottom hole assembly also includes a *neutron* detector 62, which responds primarily to the accelerator output (see col. 6, lines 53-58). Such a detector is commonly referred to a neutron source monitor. Response of the *neutron* source monitor 62 is used to correct or "normalize" the measured responses of the other detectors for variations in neutron output from the accelerator neutron source in order to obtain accurate determination of formation parameters of interest.

Claim 10 (dependent upon claim 8 and intervening claim 9) and claim 22 (dependent upon claim 18) recite the use of first and a second *gamma radiation* spectra energy regions of about 3 MeV to about 7 MeV, and from about several hundred keV to about 3 MeV, respectively, to obtain a measure of density. The Examiner ***again*** states that it would have been obvious to one of ordinary skill in the art to modify the *Tittman* method to include (a) a first energy ranging from about 3 MeV to 7 MeV, and a second energy region ranging from about several hundred keV to about 3 MeV, as taught by *Loomis*. ***Once again, this is not technically possible*** since the *Tittman* uses a gamma ray source (preferably $^{137}$Cs) with a maximum energy of about 0.660 MeV. Stated another way, there is no radiation produced by the *Tittman* system above 0.660 MeV, thus measurements in an energy region between 3 MeV and 7 MeV would be null and meaningless. The *Tittman* gamma ray source certainly does not *induce* gamma radiation in this energy range. The Examiner's comments at page 11, last paragraph, are not clear. Examiner *seems* to be suggesting the interchange of a $^{252}$Cf ***neutron*** source with a $^{137}$Cs ***gamma ray*** source to obtain a higher energy ***gamma ray*** source in the Tittman tool. For reasons discussed above, an interchange of gamma ray and neutron sources is not feasible, is meaningless, and would not be attempted by anyone of ordinary skill in the art.

Claim 20 recites

> 20. The apparatus of claim 18 wherein said induced gamma radiation comprises energies greater than about 3 MeV.

Claim 22 also recites an energy range greater than about 3 MeV. Once again, using the energy range of about 3 MeV from *Loomis* with the *Tittman* system would be ***technically meaningless*** since there is no radiation produced by the *Tittman* system above about 0.660 MeV, and substituting the neutron source of *Loomis* for the gamma ray source of *Tittman* is ***technically meaningless***.

Once again, recall that the instant invention requires *no neutron measurements*. No monitoring of neutron source output is required. *No neutron detectors are recited*. No accelerator neutron monitor is recited. Any hypothetical combination of the system of *Tittman* with the system of *Loomis* would include a plurality of neutron radiation detectors, a plurality of gamma radiation detectors, and a neutron monitor detector 62. The hypothetical combination comprises more elements of differing types than required by the instant invention. The hypothetical combination would also require more data processing steps than the instant invention.

In view of the above discussion, claims 10, 20 and 22 are clearly patentable over *Tittman* in view of *Loomis*. The Examiner is respectfully requested to reconsider rejection of claims 10, 20 and 22 under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view if *Loomis*.

Claims 12, 17, 23 and 26 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view of U.S 5,767,510 to Michael L. Evans (*Evans '510*). Applicant respectfully traverses the rejections.

*Evans '510* discloses a logging system comprising a $^{252}Cf$ *neutron* source. *Tittman* discloses a logging system comprising a *gamma ray* source. Once again, neutron and gamma ray sources are different. The neutron source of *Evans '510* can not be interchanged with the gamma ray source of *Tittman*, as discussed in detail in earlier sections of this response. Readers of this response will be spared a repeat the reasons.

There is *no teaching or motivation* in the prior art to suggest the use of the *neutron* source of *Evans '510* in a logging system designed to used a *gamma ray* source, such as the pad type density logging system of *Tittman*. Furthermore, the use of the neutron source of *Evans* in the gamma ray logging system of *Tittman* would be *inoperable*, since *Tittman* determines density using gamma radiation *down scattered* from a relatively low energy gamma ray source such as $^{137}Cs$. Recall that down scattered gamma radiation differs from down scattered neutron radiation, thermal neutron capture gamma radiation, and inelastic scattered gamma radiation. Detector collimation, pad design, detector energy biasing, and system calibration of the *Tittman* logging are all designed to measure this relatively low energy *down scattered* gamma radiation. The substitution of the *Evans '510* $^{252}Cf$ neutron source for the *Tittman* gamma ray source would produce neutron fluxes and neutron induced gamma radiation fluxes (resulting from neutron inelastic scatter and thermal neutron capture) at the *Tittman* detectors. These higher energy neutron radiations and neutron induced gamma radiations would not meet design criteria of the *Tittman* system. The *Tittman* system is not designed to measure and process these radiations. As a result, no measure of formation density could be obtained using a combination of *Tittman* and *Evans '510*. Claims 12, 17, 23 and 26 are, therefore, clearly patentable over *Tittman* in view of *Evans '510*.

Regarding claims 17 and 26, a cursory inspection of the *Tittman* device (as shown in Fig. 1) will lead anyone skilled in the art to the obvious conclusion that (a) if such a device were mounted on a drill string, and (b) the drill string were rotated to advance the borehole, then (c) the pad would immediately be "sheared" off and the system would be inoperable. Inherent problems of shearing of pad type wireline devices of the *Tittman* type were, in fact, a key motivation to develop non-pad type devices for measurement or

logging-while-drilling applications. The instant logging tool is not a pad type device, and is therefore applicable to drill string conveyance and logging-while-drilling applications. Both wireline and logging-while-drilling embodiments of the instant logging system are discussed in detail in the instant specification. A combination of *Tittman* and *Evans '510* would, therefore, be ***inoperable.*** Claims 17 and 26 are, therefore, further distinguished over *Tittman*, in addition to being dependent upon claims 1 and 18, respectively, which are clearly distinguished over *Tittman* in view of *Evans '510* as discussed previously.

In view of the above discussion, the Examiner is respectfully requested to reconsider rejection of claims 12, 17, 23 and 26 under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view if *Evans '510*.

Claims 27-29 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view of U.S Re. 36,012 to William A. Loomis et al (*Loomis*). Applicant respectfully traverses the rejections.

*Once again, the Examiner **MISQUOTES** Tittman.* The *Tittman* system used a *gamma ray source and **not** a neutron source.* An examination of only element (a) of claim 27 clearly shows that *Tittman* is ***misquoted*** and can not be used as grounds for rejection. Referring to the preamble and element (a) of claim 27, as referred to in previous responses:

> 27. A method for determining bulk density of an earth formation penetrated by a borehole, the method comprising the steps of:
>
> (a) inducing gamma radiation within said formation by means of a *neutron* source;

**Examiner's references:** col. 2, lines 42-49 and col. 3, line 65 to col. 4, line 53.
**Applicant's comments**: Regarding col. 2, lines 42-49, line 42 clearly recites "The tool contains a *gamma ray* source". Col. 3, line 65 to col. 4, line 53 discloses various components of the apparatus, and the effects of "high Z" materials discussed previously. There is *no* mention of a neutron source, simply because none is taught by *Tittman*. The neutron source of *Loomis* can not be substituted for the gamma ray source of *Tittman*, for reasons discussed previously and at length.

Independent claims 28 and 29 both recite a *neutron source* at element (a). As in the discussion of claim 27, *Tittman* teaches *only* the use of a *gamma ray* source.

There is no *motivation* for a combination of *Tittman* and *Loomis*, and any type of hypothetical combination would be ***inoperable***, for reasons detailed above. Stated simply, a system based upon a gamma ray source (*Tittman*) and a system based upon a neutron source (*Loomis*) are *not* combinable as the Examiner seems to believe. The Examiner is respectfully requested to reconsider rejection of claims 27-29 under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view if *Loomis*.

The Examiner is respectfully requested to consider the above remarks and to allow pending claims 1-29 as filed.